Existing Sustainable Renovation Concepts

Tommerup, Henrik M.; Vanhoutteghem, Lies; Gustavsson, Leif; Mahapatra, Krushna; Haavik, Trond; Paiho, Satu; Ala-Juusela, Mia

Publication date:
2010

Document Version
Publisher's PDF, also known as Version of record

Successful Sustainable Renovation Business for Single-Family Houses - SuccessFamilies

The project is part if the Nordic Call on Sustainable Renovation
NICe project number 08191 SR

Deliverable 1.1
Existing sustainable renovation concepts

WP Leader: **DTU Technical University of Denmark**

Nordic Innovation Centre

Deliverable Administration & Summary			
No & name	**D1.1 Existing sustainable renovation concepts**		
Status	Final	**Date**	2010-02-18
Author(s)	Henrik Tommerup, Lies Vanhoutteghem, Svend Svendsen, DTU Technical University of Denmark ; Krushna Mahapatra, Leif Gustavsson, Mid Sweden University ; Trond Haavik, Synnöve Aabrekk, Segel AS; Satu Paiho, Mia Ala-Juusela, VTT Technical Research Centre of Finland.		
Editor	Henrik Tommerup, DTU		
Application	Sustainable renovation concepts addressing single-family houses based on literature, virtual surveys on the internet, expert networks etc. The other Deliverables of WP1: - D1.2: Report on the analysis of the most promising concepts selected from D1.1 - D1.3: Proposals on new better sustainable renovation concepts suitable for different categories of single-family houses with regard to type and age.		
Comments			

Document history			
V	**Date**	**Author**	**Description**
1	2009-08-04	DTUHT	“Table of content”
2	2009-09-23	DTUHT	Draft 1
3	2009-11-02	DTUHT	Final Draft 1
4	2009-11-17	DTUHT	Final Draft 2
5	2010-02-18	DTUHT	Final D1.1

Table of contents

1 EXECUTIVE SUMMARY

1.1 Publishable summary

The Nordic single-family house renovation market is dominated by a craftsman based approach with individual solutions, traditional warehouses ”do-it-yourself-shops” and some actors marketing single products. To speed up the implementation of sustainable renovation of single-family houses there is a great need for full-service packages including consulting, contract work, follow-up, financing and operation and maintenance. There are few Nordic examples of such service models for renovation of single-family houses which entered the market recently. The success of these concepts is yet to be evaluated.

One successful full-service package described in the report is a campaign by an energy company in Sweden who convinced 78% of 456 owners of houses with resistance heaters to connect to its biomass based district heating network. The campaign was successful because of its package offer and information provision with emphasis on economic aspects and functional reliability.

The existing technical renovation concepts, typically focussing on application of only a few of the available technical solutions, have not been successful in realizing large scale energy efficiency gains. Renovation of single-family houses might be carried out based on design solutions with good combinations of the possible range of technical solutions including e.g. “passive (insulation) measures” and “solar measures” in order to reach a low primary energy level. Key aspects of reaching a low primary energy level in connection with renovation are described in the form of typical energy renovation measures and technical principles of low energy renovation including recommended extent of measures.

Full service and technical renovation concepts should make it easy, simple and secure for the consumer to invest in a low energy renovation of their house. The building sector needs easy to use knowledge and initiatives which ensures that they can offer solutions which fulfil the demand for quality, economy and a simple process. To speed up the implementation of sustainable renovation of single-family houses, society needs to stimulate the process including better incentives structures, e.g. increased tax on energy and/or subsidy programmes. Combined with an outlook for rising global energy prices, sustainable renovation of single-family houses then has the potential to become an important market area in the future.

2 INTRODUCTION

2.1 Purpose and target group

The purpose of this work is to get an overview of the existing sustainable renovation concepts, i.e. full-service concepts and technical concepts, for single-family houses.

The term "sustainable" includes many environmental, social and economic indicators. In this project, sustainable renovation is defined with emphasis on primary energy use[1], but without disregarding the other indicators. A sustainable renovation concept is defined as:

"A concept that results in cost-effective renovation of a house with substantially better energy performance, coupled to a mainly renewable energy supply system, and improved indoor environment. The level of total primary energy use should be preferably equal to a new house built according to standard building code requirements or better" [2]

The definition is considering that there might be limited possibilities of introducing energy efficient renovation measures in some buildings, e.g. those worthy of preservation.

To ensure that renovated houses can compete on energy performance with new houses when they are sold, house owners may want to consider the government's plans for introduction of low energy standards for new houses as minimum requirements. In the current Danish Building Regulations two low energy classes are in force as optional possibilities: low energy class 2 and low energy class 1. The two classes are defined as having a calculated energy performance that is 25 and 50 per cent respectively better than the minimum energy performance for new buildings. In 2010 it is planned that low energy class 2 will be the new energy performance limit in the Building Regulations and in 2015 it is assumed that low energy class 1 will be the minimum requirement. It is the government's target that by 2020, all new buildings use 75 % less energy than new buildings constructed according to the current Building Regulations. Similar initiatives and plans are ongoing in Sweden and Norway with the purpose of establishing a definition and a development towards low energy buildings [2]. In general, the current recast of the EPBD (Directive 2002/91/EC on energy performance of buildings) is an opportunity for the European Commission to introduce a request to member states to define very low-energy buildings at national level, to draw up a national strategy towards this level of energy performance, and to put focus on upgrading energy performance of the existing building stock.

A full-service concept can be defined as a documented series of actions that can be repeated and that produces individual renovated buildings aiming at fulfilling the defined requirements optimally. The term full-service renovation concept indicates that all relevant steps necessary for the renovation of the building are included - from planning, over demolition to cleaning and maintenance afterwards. Typically, the requirements are defined by the homeowner and building code, e.g. requirements to heat loss (U-values), energy performance (energy

[1] For a building, primary energy use is the energy used to produce the energy delivered to the building. It is calculated from the delivered energy and exported amounts of energy carriers, using conversion factors. Primary energy includes non-renewable energy and renewable energy. If both are taken into account it can be called total primary energy [1].

[2] A wider definition is for example used in the doctoral dissertation: "Towards Sustainable Renovation – Three research projects", Marina Botta, School of Architecture, Royal Institute of Technology, Stockholm 2005

consumption), indoor environment (indoor air quality, thermal comfort and daylight) and architectural quality. Some full-service concepts described in this report may not include technical measures that qualify them to be "sustainable" according to the definition but they are included due to the lack of concepts in the participating countries.

A technical renovation concept is defined as a package of solutions targeted to a certain category of house (type and age). The package of technical solutions carried out during an overall or step wise planned renovation is a good combination of the full range of technical solutions, especially in order to reach a low energy level.

Buildings vary in age, size, architecture, technical standards, and location. In addition to these, availability of skilled work force, financing mechanism, and above all the awareness, interest and demographic characteristics of the occupant influence the form and degree of renovation of buildings. Hence, a standard renovation concept may not be applicable to all types of typical buildings. Each renovation project with different framework conditions may need to be evaluated separately. The concepts are described with this constraint in mind.

The results presented in the report may be useful for everyone involved in sustainable renovation of residential buildings, especially single-family houses.

2.2 Contributions of partners

All partners have contributed with descriptions on existing full service renovation concepts using a template provided by DTU. Parallel to this work the participants have contributed with input to the description of the technical renovation concepts and the gathering of information on existing building stock analyses to be used in D1.2.

2.3 Relations to other activities in the project

Based on D1.1 the most promising concepts are indentified with regard to greatest primary energy savings potential etc. These concepts will be detailed analysed in D1.2. The typical single-family houses with the greatest primary energy saving potential in the Nordic countries - based on a review of existing building stock - will also be analysed in detail. The detailed analyses will be carried out regarding how to reduce the final energy use to a very low level, i.e. overview of possible energy renovation solutions taking into account both heating and cooling demands and indoor comfort requirements. Other aspects to be analysed are plans for implementation of energy renovation, durability issues, user needs and total life cycle cost. Based upon the analyses, better concepts suitable for different categories of single-family houses (type and age) will be proposed in D1.3.

3 FULL SERVICE RENOVATION CONCEPTS

Full service renovation concepts aimed at single-family homeowners exist in the Nordic countries but they are not well established. Currently, the renovation market is dominated by a craftsman based approach with individual solutions, traditional warehouses ”do-it-yourself-shops” and some actors marketing single products.

Information on full-service concepts in the participating countries has been collected and is briefly presented below, including the following information, if available:

- Country - Denmark, Sweden, Norway or Finland
- Name - concept name (e.g. abbreviation and full name)
- Facilitator - organization in charge of facilitating the renovation process
- Partners - others involved in providing the “full service”
- Target group - who is the main target group?:
    - House (type and/or age)
    - Living situation (change of ownership, existing residents)
    - People (income, education, attitudes) - mostly the climate concerned, comfort oriented or cost oriented?
- Service package - a general description of how the concept works and the services included
- Impact - has the concept been a success among the targeted single-family house owners
- Technical solutions - building envelope, building services systems and energy systems
- Energy saving potential - reducing primary energy use
- Other aspects - comfort, architecture/style, health, safety etc.
- Advantages
- Improvement potentials
- More information – Link to homepages, reports, articles, contact person

3.1 Denmark

3.1.1 Clean Tech - New energy - Clean savings

This concept was introduced May 1st 2009. The facilitator is Dong Energy A/S, one of Northern Europe's leading energy groups, who runs a business based on procuring, producing, distributing, trading and selling oil, gas, and electricity, and related products in Northern Europe. Dong Energy collaborates with a window manufacturer (Pro Tec Vinduer A/S), a heat pump supplier (Danfoss A/S), an insulation manufacturer (Rockwool A/S) and a financing company (Dan-Aktiv A/S). The targeted market segment is the oil-fired old detached single-family houses with easy-to-carry-out measures/investments with a short pay-back time. Dong's interest in the market for energy renovation is to earn money and keeping up a good image and loyal costumers but is also related to a commitment to document energy savings (see below).

The concept idea is to offer customers a one contact service (Dong Energy). The homeowner visits the concept homepage and tries out the calculator "Test your house" and gets an idea of relevant renovation measures and the energy saving potential or calls Dong Energy directly. Then the home owner can contact Dong Energy for telephone advice on the most interesting solutions or Dong Energy contacts the costumer based on the typed in information. Dong Energy contacts relevant installers, who make a visit to the house to determine the optimal solutions. A quote on the total renovation is send to the customer together with a flexible loan offer of DKK 15,000 – 150,000 (EUR 2,000 – 20,000). Dong Energy will offer to handle a possible application for national renovation subsidy and to take care of any other necessary paperwork and allowances. After an acceptance of the quote and possibly a loan, the renovation work is carried out by the same installer that inspected the house. Dong energy offers a five-year guarantee.

According to Dong Energy's homepage, the concept has a potential for energy savings of up to 50% for each house. For an average old house, this corresponds roughly to the energy standard of a new house built to meet the minimum requirements of the building code. At the moment they are concentrating on two concepts: EnergyMinus and EnergyPlus. The first aims at saving energy with new windows and easy-to-carry-out insulation measures such as cavity wall insulation. The latter is providing house owners with more efficient energy supply such as heat pumps (ground heat or air to water). The heat pumps are especially relevant in the around 100,000 houses in Denmark that have oil-fired burners older than 10 years.

The energy saving potential is fairly limited as only cavity wall insulation is offered as part of the package. Cavity wall insulation does not ensure a uniform and unbroken insulation layer without thermal bridges like e.g. an external insulation solution. Cavity wall insulation reduces the U-value from about 1.5 to 0.4-0.7 W/m^2K, whereas an external insulation of 200 mm mineral wool will reduce the U-value to 0.15 W/m^2K. Ventilation with heat recovery is not part of the concept. Both external insulation of facades and ventilation with heat recovery have great potential for end-use energy savings and also a better indoor environment.

As part of the agreement with the home owner, Dong Energy has secured the right to report the realized energy savings to the Danish Energy Agency. They are committed to document a certain amount of energy savings each year like any other Danish utility company.

After introduction of the concept there has been encouraging response from the targeted homeowners, but it is too early to conclude if it has been a success. The concept is aimed at

energy saving measures with a short pay-back time – one could say measures that anyhow might have been carried out. Improvements to the concept may be to include further-reaching measures like ventilation with heat recovery and internal and external wall insulation.

More information: Troels Øberg, Head of Cleantech, Dong Energy Sales & Distribution (http://www.dongenergy.dk).

3.1.2 Climate Construction – A focused effort for energy efficient renovation of existing residential building

This service concept is not yet on the market (expected late 2009). The concept is developed by a group of companies, led by the contractor NCC Construction Denmark A/S. The other participants are companies in the business areas of roof windows & skylights, vertical windows, thermal solar energy, decoration & sun screening and ventilation & indoor climate (VKR Holding), a heating solutions manufacturer (Danfoss A/S), an insulation manufacturer (Rockwool A/S) and a mortgage lending company (Nykredit A/S). The targeted market segment is standard housing estates suited for energy renovation, typically erected in 1950 to 1980.

The concept idea is to offer customers a one contact service (NCC) with focus on individual renovation solutions based one their needs. A web site shall present the product and make it possible to make a rough estimate of the energy saving potential. NCC wants the customer to experience a thorough and educationally examination of the existing building including blower door test, thermograhy and a virtual model of the building for overview of possible solutions regarding energy saving potential, comfort, improvements and maintenance aspects.

The individual solution offered, results from a configuration of standard solutions picked from the product categories of building envelope, energy supply, active measures, electricity consumption, behavioural guidance and financing, and the overall renovation package thereby remains economically attractive. The customer is presented a total package solution including financing and management of the renovation process. After the renovation the customer receives an energy certificate.

More information: Martin Manthorpe, Managing Director, Strategy and Business Development, NCC Construction Denmark A/S (http://www.ncc.dk).

3.1.3 Passive house renovation – Pilot project in Hjørring, North Jutland

In the city of Hjørring in the far north of Denmark, a small local construction firm (Parvenu ApS) and architect (Bjerg Arkitektur A/S) have joined forced with the objective to show that it is not expensive and difficult to renovate older energy-intensive houses to passive house standard. The incentive for the construction firm to engage in high quality renovation and new building was the assumption that there will always be such a market. The motivation of the architect was linked to a yearlong involvement in passive house construction and hereby good experience and expertise in the concept. Therefore it was obvious for the parties to carry out a pilot project with the aim of providing future passive house renovation service for home owners in the region. The project includes three typical Danish single family houses, a so-called “Patriciervilla” from 1923, a “Funkisvilla from 1936, and a standard house from 1966. The facilitators cooperate with leading Danish suppliers of energy efficient products: Rockwool, Rationel Vindows, Nilan, Lauritz Knudsen, Dafa and Xella. Until now only the last-mentioned villa has been renovated (completed august 2009).

The overall expectation of the project is that the villas in the future could be heated for an amount of DKK 1000-3500 per year unlike the DKK 17,000 to 37,500 before the renovation, corresponding to savings of DKK 25,000. The construction firm estimates that the extra construction cost for renovating to passive house standard compared to a new house level of

energy performance is estimated to about 10%. There is no construction cost information available but a conservative estimation is that the pay-back time of the additional energy related investment is below 10 years.

The experiences from the first passive house renovation is that the concept, that earlier only has been professionally used in new building, can be applied on the existing residential building stock as an attractive alternative to traditional energy renovation.

More information (in Danish):

http://www.pressport.dk/pressrelease/Fra-energisultent-typehus-til-villa-i-passivhusstandard-7633.aspx

http://www.bjerg.nu/files/pdf/passiv_brorsonsvej/081026passivhus_brorsonsvej.pdf

3.2 Sweden

3.2.1 Sustainable renovation of heating systems

Primary energy use can be reduced significantly by replacing resistance heaters with district heating system. But, there is a general perception in Sweden that it is difficult to convince large number of homeowners with resistance heaters to connect to district heating system, which is necessary to create sufficient heat demand to justify the investment in the district heating network. However, the municipality-owned energy companies in the city of Östersund (2005 - 2006) and Växjö (in 2002) have applied a rather similar marketing campaign to convince a large number of homeowners in their respective cities to connect to the district heating network. The case study in Östersund is discussed below.

The about 700 houses in the Odensala district of Östersund (Central Sweden) were built mostly during the 1970s and were heated with resistance heaters. A survey in June 2005 showed that 84% of these homeowners did not intend to replace their heating systems over the coming 4 years, even though it was economically and environmentally beneficial to replace resistance heaters with district heating, heat pumps, or pellet boilers, for which a government investment subsidy was available. However, by the end of 2006, a market campaign by the energy company “Jämtkraft” convinced 78% of the 456 homeowners of all age and income group to sign contracts to connect to its biomass-based district heating network. The campaign was successful because of its package offer and information provision, which addressed factors that were important in homeowners’ choice of heating system. The survey prior to the campaign showed that homeowners gave priority to economic aspects and functional reliability, and preferred to collect information from installers and interpersonal sources.

Jämtkraft’s package offer included de-installation of the existing resistance heaters, installation of water-based heat distribution system and heat exchanger, connection to the district heating network, guaranteed delivery of hot water, heat and electricity during the renovation period, a 2-year guarantee on the installed system, a fixed price for each installed radiator, a fixed cost for extending the district heating network to a house, and a fixed district heat price (which was lower than the prevailing electricity price) for 5 years. Of the total investment cost, 30% could be obtained as a government investment subsidy and the company facilitated the homeowners to apply for it. Jämtkraft made arrangements with a bank, which was willing to provide 30-year amortizing loans at a low interest rate (about 2.5% including fees, before tax deduction). The offer also included an option for the homeowners to get a discounted price for connection to Jämtkraft’s fibre optic broadband network through which multiple companies provide internet service. The company hired two installation firms to carry out the in-house installation works.

Jämtkraft initiated its marketing campaign in June 2005 by informing the homeowners through home-delivered leaflets that it was planning to expand the district heating/broadband network to Odensala. The leaflet included a one-day free entry ticket for the households to visit an annual trade fair in Östersund, where Jämtkraft had a stall about district heating. Subsequently, it invited the homeowners to attend information meetings, which were organized at a well-known meeting place close to Odensala (in the evening), the company's own premise, and at the local Christmas market. The invitation letter included a booklet which contained explanation of the advantages of district heating, how it functions, the installation process, examples of the experience of existing customers, and frequently asked questions. A thank-you note was sent after the meetings. In all these meetings, representatives of the installation firms and the bank participated to answer homeowners' questions. In December 2005 Jämtkraft sent the package offer to all homeowners. In February 2006, a demonstration vehicle was parked in Odensala to demonstrate the functioning of the district heating system.

More information: Krushna Mahapatra (Krushna.mahapatra@miun.se) or the paper "Influencing Swedish homeowners to adopt district heating system" [3].

3.2.2 Energy efficient renovation of detached house - Villa Kanndalen

In Sweden, a market opportunity for renovation of detached houses exists. For example, about 500,000 houses were built during 1961-76 before a new building code with higher energy standard was introduced in 1977. These houses are typically heated with resistance heaters and have low energy efficiency standards. Villa Kanndalen in Öckerö, which is a typical detached house from the 1970s, was renovated to a low energy house standard. The energy use for heating and hot water purpose has reduced by 70%, from 162 kWh/m^2/year to 49 kWh/m^2/year.

Before renovation the house had cracks in its façade and doors and windows were in bad condition. The owner of the Energieffektiva Hus AB company could convince the homeowner, a relative, to go for energy efficient renovation [4]. The homeowner opted for energy efficient windows and improved insulation with an additional cost of SEK 220 000 (EUR 22 000) compared to a traditional renovation.

The house renovation included construction of a new roof over the existing roof to a passive house standard, instead of renewing the existing roof. The walls of the old attic were covered with air tight foils. The space below the ground flooring was additionally insulated. Furthermore, resistance heaters were replaced with a ventilation system with heat exchangers.

Energieffektiva Hus led other companies such as Isover, Elitfönster, Effekta, Maxit, Rec Indovent, and Andersson & Hultmark, which participated in the renovation project. The consulting company IMCG acted as an adviser. This consortium of companies also builds passive houses.

When a customer approaches Energieffektiva Hus for energy efficiency renovation, the company analyzes the existing household energy use in relation to the condition of the house, and estimates the potentials for efficiency improvement of various combinations of measures. Investment costs and financial saving potentials are part of the analyses. A solution that matches the customer's requirement is recommended.

The company does not take a proactive role to reach prospective customers of renovation. Furthermore, the renovation service model does not include financial arrangements.

Information Villa Kannadalen (in Swedish):
http://www.newsdesk.se/view/pressrelease/smaahus-ny-marknad-foer-energieffektiv-renovering-298323

Information Energieffektiva hus: http://www.energieffektivahus.se/

3.3 Norway

3.3.1 JADARHUS Rehab - Single-family house producer established own daughter company for the renovation market.

The company Jadarhus Rehab AS was established late summer 2007 by Jadarhus AS (132 mill NOK in 2008), which designs and builds new single-family houses and smaller apartment buildings. The group sees potential in the retrofitting market, and decided therefore to found a separate company to develop this market. In 2008 Jadarhus Rehab AS achieved a turnover of nearly 32 mill NOK (EUR 3,85 mill) and a net result of nearly 3 mill NOK which is a very good achievement for a new company. Their partners are: IHT (Architects), Nordic Dørfabrikk AS, Skarpnes (tiles), Velux, Optimera, HTH Kitchen, and some others.

Jadarhus is located in Stavanger and its market is the south west region of Norway. Their target group is people who instead of buying new land to build their own house, have concluded they want to buy an old house which they can renovate.

They assist the customer throughout the full process, and energy efficiency is only one part of the package. Here are some arguments from their brochure:

- We would like to contribute to realise the potential in every existing house.
- We take into account the right architectural choices in respect to the environment of the house as well as the original style and form of the house.
- We put emphasis on choosing the most economical and environmental friendly solutions.
- We increase the value of your house through good architecture and solid handcraft.
- We take the responsibility from A to Z.
- We create opportunities in a market with lack of available building sites and high prices.
- We cooperate with the best suppliers in the building industry.

Jadarhus Rehab starts the process with a meeting with the client, in which they study the potential of the house. Based on this, they plan a building process which is similar to the process for a new house.

Their technical solutions are tailor-made to the customer's wishes. Regarding energy efficiency initiatives, they describe these examples: Easy actions such as additional insulation in cold attics, new windows with lower u-values and reduced draft and air leakages around the window, change of outside panels and build in new windproof layer, as well as checking the passages between the foundation wall and the tier of beams, outer wall and roof, additional tightening of windproof materials and jointing around critical parts. Advanced measures such as additional layer of insulation, either on the inside or outside of the wall, building walls between warm and unheated rooms, attics to be outfitted may be additional insulated either on the inside or the outer part of the roof. The energy savings potential depends on actions.

Jadarhus Rehab has strong focus on market value, architecture and comfort. They are one serious actor which takes care of the whole process. However, they can improve on tools to

demonstrate the customers how the house will be like after the renovation, ventilation system, financing package, monitoring system and a better marketing approach.

More information: (http://jadarhus.no/images/stories/downloads/rehabilitering.pdf)

3.3.2 El-sjekken

Huseieners Landsforbund and the electro installation chain "Sikringen" have targeted members of the Norwegian House Owner Association with a service package on an audit of the electric system in the house. The purpose is to reduce the risk for fire as well as identifying potential for energy saving. The ordinary price is NOK 1500 but members of the association get NOK 500 discount. The impact is not known.

Technical solutions are limited to an audit. However, as it results in recommendations for actions, this means business potential for the electro installer. The service package is cheap which means it is easy to decide to buy it. The scope of the service package is very limited, so there is potential for general improvements.

More information: http://www.huseierne.no/Medlemsfordeler/sikringen

3.3.3 ENOVA Grants and advices for energy measures

Enova is the stately owned energy efficiency agency. Enova has in cooperation with several manufacturers of building materials targeted all Norwegian households with a service package based on information on the WEB, including instant chat function and call up number for speaking with an advisor. The household can apply for grants limited to 20% of the costs of these investments:

- Pellet fired heating appliances, limited to NOK 4.000
- Liquid/water heat pumps, limited to NOK 10.000
- Air/water heat pumps, limited to NOK 10.000
- Central regulated heating system, limited to NOK 4.000
- Solar collector, limited to NOK 10.000

Enova has paid grants to 10.400 households since the launching in October 2006. These households, counting 35.700 persons, have invested 900 mill NOK (EUR 108,5 mill) in energy measures. By June 2009 the number of accumulated applications reached 33.000.

The energy savings potential depends on actions and uncertainty regarding rebound effect. The financing scheme is linked to advising services through their homepage and call center.

The ENOVA Grants and advices for energy measure have a narrow focus on simple actions and no face to face advising service and can be improved especially on these two aspects.

More information: http://www.minenergi.no/

3.4 Finland

3.4.1 ENRA - Program for energy efficient renovation and living

ENRA is an abbreviation of "Energiatehokkaan remontoinnin ja asumisen ohjelma", The program for energy efficient renovation and living). ENRA started in January 2009 as a pilot program in the Pakila area in Helsinki. This is an area with typical single-family houses from 1940-50's (mainly so called "Veteran houses") and from 1960-70's. The experiences are very limited as the concept was only launched recently and no renovations have yet been finished.

Now the concept is also being launched to other areas, by recruiting and educating more ENRA experts.

The concept was developed by a group of companies, led by a renovation company (Rustholli Oy). The other participants are a window and door manufacturer (Domus Group Oy), a ventilation system manufacturer/supplier (Enervent Oy), an insulation manufacturer (SPU Systems Oy), an energy certificate supplier (Raksystems Anticimex Oy) and a heat pump supplier (Thermia Partners Oy). VTT has supported the concept development.

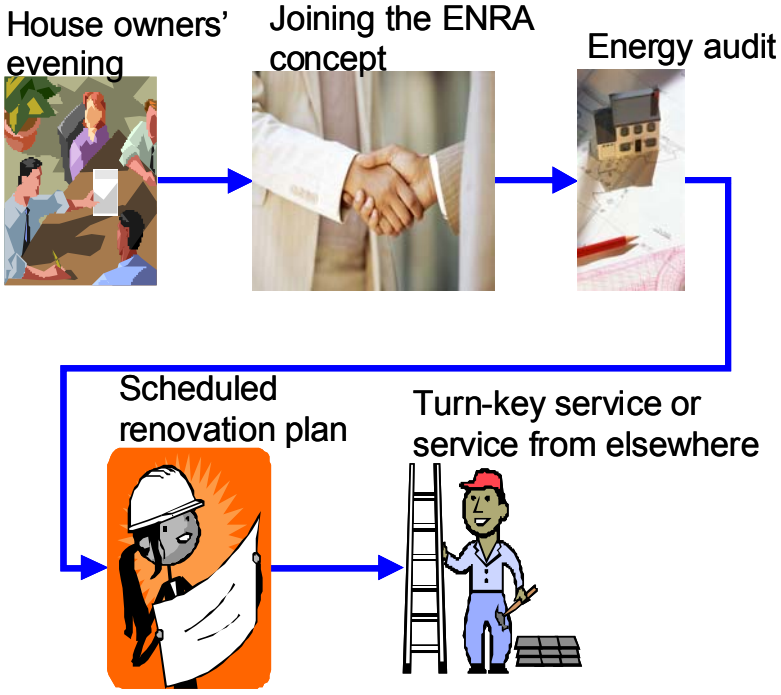

Figure 1. The ENRA concept.

In Figure 1, the ENRA philosophy which is discussed more in detail in the following text, is shown. Potential clients are invited to participate in a house owners' evening. The effects of climate change and the role of buildings in it are explained to the audience. Then the actions taken by the global community, European Commission and governments are presented. The possibilities of the house owner to contribute are described with an outline of the different renovation actions that help combat the climate change. Other benefits from energy renovation improvement of thermal comfort and air quality are also discussed. The participants in the house owners' evening are then offered the possibility to join the ENRA program. They will fill in a contact information sheet, if they want Rustholli's ENRA expert to take contact with them.

In a short notice, an ENRA expert will contact the customer to set up a date for an energy audit. In the energy audit, the house will get an energy certificate, an estimation of the most suitable energy efficiency improvement actions, and a cost estimation.

After the energy audit, the ENRA expert will visit the customer, to find out the individual renovation needs of the family in question. All renovation needs are mapped and their priority order is noted. They might include renovation that has nothing to do with energy, but a lot to do with the living comfort. A time schedule is set up according to the needs, financing possibilities and other circumstances of the family. After this, the customer is free to choose other service providers, or buy the turn-key service from the ENRA-group. With the turn-key service, the customer also gets a list of pre-chosen alternatives from the material and device producers in the ENRA-group. The ENRA expert will also look for other suppliers, if the customer wants something that is not covered by the ENRA-group, e.g. solar heating systems.

Rustholli Oy uses only A-labelled windows for the ENRA-houses. Insulation products are based on polyurethane which has an about 30% lower thermal conductivity than for example mineral wool (widely used in Denmark) and is therefore especially suited for typical Finnish internal insulation solutions. In general many wooden finish houses have got a brick or other heavy rain shield and many of these houses can be improved visually by using a thermally more effective external insulation solution with less thermal bridges and a new rain shield.

The pre-chosen ventilation system has heat recovery based on the rotating wheel (annual heat recovery rate up to 73 %) in order to cope with the very low winter temperatures. The same units can be used for heating, heat recovery and cooling. Heat pumps are offered as a fairly cost and energy efficient energy supply solution (many houses are electric heated) after a renovation that has reduced the energy demand significantly.

More information: Kari Hirvijärvi, Managing Director, Rustholli (http://www.rustholli.fi)

3.4.2 Senera energy renovation

The heat use in residential buildings is often high and living comfort is not very good. In order to reduce big heating costs and ensure a comfortable indoor climate, the company SENERA Oy provides a full service renovation package including multifaceted renovation alternatives. The main intervention consists of replacing existing heating systems based on oil or electricity in houses in the South of Finland or larger buildings such as office buildings and hotels, by installing ground source heat pumps, air heat pumps or air-water heat pumps or the installation of low temperature floor heating instead of electrical or waterborne radiators for more effective use of the heat pumps. All types of heat pumps are used from IVT, a Swedish heat pump manufacturer that is part of the well-known BOSCH-group.

Besides the improvement of the heating systems, SENERA Oy suggests a renovation of the ventilation, windows and facade and the addition of insulation in the roof and walls. For the additional insulation, the company works together with the insulation manufacturer Ekovilla that provides insulation based on cellulose fibres.

The company (SENERA Oy) claims that with renovation according to their proposed measures the heating costs, excluding the investment cost, can be reduced up to 80%. However, the precise impact on reduced heating demand depends on the undertaken actions and is not known.

The advantage of the package offered by SENERA Oy is that only one contracting party needs to be addressed. Moreover, the company offers costumers a renovation plan, warranty service and user guidance. However, some future improvements such as financial aspects, an extensive energy audit and an examination of the condition of the building and the use of solar energy systems could be included in the package.

More information: http://www.senera.fi/page.php?id=54 (in Finnish)

3.4.3 LLK energy renovation

When houses are being renovated, it is not only of interest to replace several building components, it is also advisable to increase the energy efficiency of the building components such as roof, exterior walls, foundations, floors. The LLK energy renovation concept is developed by LLK-Remontit in order to increase energy efficiency while renovating buildings and prepare buildings to comply with the future energy requirements. LLK-Remontit collaborates with an insulation producer (Paroc Oy Ab) and several building material suppliers.

The company offers a full renovation package, from planning to maintenance, including the calculation of the renovation costs and a free energy calculation of the property. Based on the performance of each property, different renovation solutions regarding windows, insulation improvements of roof, walls and foundations, changes in the heating system or ventilation, plumping and sanitary work in kitchen and bathroom, are suggested in order to reduce the energy use while preserving the living comfort. The targeted market segment consists of old timber houses, veteran houses, wood construction mineral wool insulated houses from 1960's and 1970's and cottages.

The energy saving potential of the concept depends on the renovation measures applied on each individual property.

More information: http://www.llkremontit.fi/fi/palvelut/energiaremontti (in Finnish)

3.4.4 Targenee energy renovation

The Targenee energy renovation concept is developed by the company TerMater Oy to reduce the heating demand when renovating buildings. In order to do so, the company relies on authorized partners which are however not known exactly.

The concept idea of the service package is to offer customers a one contact service (TerMater Oy). Experts of the company will determine the current energy rating of the building and a cost estimation of the energy saving by renovation, based on a benefit analysis. Depending on this analysis, the building can be renovated on a turn-key basis consisting of pre-chosen alternatives, provided by the company or on a customer-selected level. After the renovation, the company offers the costumers an energy certificate.

According to TerMater Oy, the concept delivers a saving potential for heating by up to 70% while also improving the living comfort and increasing the value of the house.

The company promotes insulation improvements and the use of air heat pumps to reduce heating demand. To improve the insulation of the walls, the company uses a new product, the TERMO-builder´s plate. The plate, made of plasterboard combined with polyurethane, acts as a vapour barrier, insulates and does not need any finishing. However, besides this product, the company does not offer many alternatives and in the future, some more extensive renovation assortments could be defined.

More information: http://www.termater.fi/targenee_energiaremontti.htm (in Finnish)

3.5 Summary of existing full service renovation concepts

Table 1. Full service renovation concepts in Denmark

Name	**Clean Tech**	**Climate Construction**	**Passive House Renovation**
Facilitator	**Dong Energy (DE)**	**NCC Construction DK**	**Parvenu, Bjerg Arkitektur (local construction firm and architect)**
Partners	Pro Tec Vinduer, Danfoss, Rockwool, Dan-Aktiv	VKR Holding, Danfoss, Rockwool, Nykredit	Rockwool, Rationel Vindows, Nilan, Lauritz Knudsen, Dafa and Xella
Target group	Old detached single-family houses – primarily oil heated	Standard housing estates suited for energy renovation, typically erected in 1950 to 1980	Owners of old energy-intensive houses, who have a robust economy and facades not worthy of preservation
Service package	One contact service including products, advice, installation, financing and maintenance. DE handles necessary paperwork and allowances (e.g. subsidy application)	One contact service and total package solution including technical renovation solutions and products, financing and management of the renovation process	Pilot project - to be developed
Impact	Introduced May 1st 2009, encouraging response from the targeted homeowners	Not yet on the market	Pilot - Not yet on the market
Technical solutions	"EnergyMinus": new windows and easy-to-carry-out insulation measures, "EnergyPlus": Heat pumps (ground heat or air to water) etc.	Building envelope, energy supply, active measures, electricity consumption, behavioural guidance	Thorough measures, focus on passive measures such as high level of insulation (externally), air tightness and ventilation system with air-to-air heat recovery, no traditional heating system
Energy saving potential	Up to 50%	Depends on actions	Very low energy renovation concept – factor 10 renovation
Other aspects	Contact to customers via homepage and "Test your house" facility, customer calls DE directly or DE takes contact based on typed in information	Focus on educational examination of the existing building, and individual renovation solutions based on customer needs	Difficult concept to use on houses worthy of preservation , e.g high quality aesthetic details on the facades
Advantages	Full-service concept, five-year guarantee is offered	Virtual model of the building for overview of possible solutions, whole range of technical solutions	Prepared for the future concept (e.g. rise in energy prices), high quality indoor environment, improved appearance of the house
Improvement potentials	Low energy renovation concept for greater energy savings and better indoor environment offering external/internal insulation of facades, ventilation with heat recovery, solar energy	More focus on single-family house but difficult market = influenced a lot by financial situation of society, energy price development, subsidy opportunities etc	Acceptable financing solutions for normal families, connection to very low energy district heating and very low temperature based in house heating system

Table 2. Full service renovation concepts in Sweden

Name	**Sustainable renovation of heating systems**	**Energy efficient renovation of detached house - Villa Kanndalen**
Facilitator	**Jämtkraft**	**Energieffektiva Hus AB**
Partners	Installation firms, bank	Isover, Elitfönster, Effekta, Maxit, Rec Indovent, Andersson & Hultmark, IMCG (adviser). This consortium of companies also builds passive houses.
Target group	Low rise built-up areas with resistance heaters etc.	Typical detached houses from 1961-76 (500,000) heated with resistance heaters and having low energy efficiency standards
Service package	De-installation of existing resistance heaters, installation of water-based heat distribution system and heat exchanger, connection to district heating network, guaranteed delivery of hot water, heat and electricity during the renovation period, a 2-year guarantee on the installed system, fixed prices including heating price for 5 years, facilitation of homeowners to apply for government investment subsidy, 30-year amortizing loans at a low interest rate (about 2.5%), discounted price for connection to Jämtkraft's fibre optic broadband network	The facilitator makes analyzes of existing household energy use, condition of the house, estimates potentials for efficiency improvement of various combinations of measures, investment costs and financial saving potentials: A solution that matches customer's requirement is recommended. The facilitator led the other companies in the project
Impact	A campaign by Jämtkraft in Östersund convinced 78% of 456 owners of houses with resistance heaters to connect to its biomass based district heating network.	Pilot project: Additional cost of energy efficient windows and improved insulation of SEK 220 000 (EUR 22 000) compared to a traditional renovation
Technical solutions	New water-based heat distribution system and heaters, connection to biomass based district heating system with heat exchanger	New roof over the existing roof to a passive house standard, old attic covered with air tight foils, the space below the ground flooring additionally insulated, resistance heaters replaced with a ventilation system with heat recovery
Energy saving potential	High primary energy savings	The energy use for heating and hot water purpose has been reduced by 70%, from 162 kWh/m^2/year to 49 kWh/m^2/year.
Other aspects	Less scope for dry indoor environment which happens with resistance heaters	Improved indoor environment, especially warmer and more air tight inner surfaces
Advantages	The campaign was successful because of its package offer and information provision with emphasis on economic aspects and functional reliability.	Involved companies have experience in low energy building
Improvement potentials	Inverted order of measures – for econmic and sustainability reasons energy demand should be reduced before introducing energy efficent supply – smaller radiators etc.	Financial service/arrangements, proactive role to reach prospective customers for renovation.

Table 3. Full service renovation concepts in Norway

Name	**JADARHUS Rehab**	**El-sjekken**	**Minenergi and Enova anbefaler**
Facilitator	**JADARHUS Rehab – originally a house producer**	**Huseieners Landsforbund**	**Enova, stately energy efficiency agency**
Partners	IHT (Architects), Nordic Dørfabrikk AS, Skarpnes (tiles), Velux, Optimera, HTH Kitchen, and some others	The electro installation chain "Sikringen"	Several manufacturers of building materials
Target group	Buyers of an old house which they can renovate	Members of the Norwegian House Owner Association	All Norwegian households
Service package	Same service as for new houses	An audit of the electric system in the house. The purpose is to reduce the risk for fire as well as identifying potential for energy saving.	Information on the WEB, including instant chat function and call number for speaking with an advisor.
Impact	Turnover: 32 mill NOK (EUR 3,85 mill) (2008) Net result: 3 mill NOK	Not known	Grants to 10.400 households counting 35.700 persons (since October 2006). These households have invested 900 mill NOK (EUR 108,5 mill) in energy efficiency measures. By June 2009 the number of accumulated applications reached 33.000.
Technical solutions	Tailor-made, (emphasis on) easy actions, advanced actions	Limited to an audit. However, as it results in recommendations for actions, this means business potential for the electro installer.	Pellet fired heating systems, heat pumps, central regulated heating systems and solar collectors.
Energy saving potential	Depends on actions	Depends on actions	Depends on actions and uncertainty regarding rebound effect.
Other aspects	Strong focus on market value, architecture and comfort.	Strong focus on fire security	The financing scheme is linked to advising services through their homepage and call center.
Advantages	One serious actor which takes care of the whole process	Cheap package which means it is easy to decide to buy it	Includes financing services and advising
Improvement potentials	Visualization, ventilation system, financing package, monitoring system and a better marketing approach.	Very limited scope	Narrow focus on simple actions, no face to face advising service

Table 4. Full service renovation concepts in Finland

Name	ENRA	Senera Energy renovation	LLK Energy renovation	Targenee energy renovation
Facilitator	**Rustholli Oy**	**Senera Oy**	**LLK-Remontit**	**TerMater Oy**
Partners	Domus Group Oy, Enervent Oy, SPU Systems Oy, Raksystems Anticimex Oy, Thermia Partners Oy and VTT as an adviser	Not known	Paroc Oy Ab	Authorized partners, but not known exactly
Target group	Primarily single-family houses from 1940-90's (mainly so called "Veteran houses")	Home owners in Southern Finland, mainly with oil or electricity heating	Old timber houses, veteran houses, wood construction wood wool insulated houses from 1960&70's	Not specified
Service package	House owners' evening, agreement, energy audit, renovation plan, turn-key service	Not specified in detail	Not specified in detail	Current status/energy rating, cost-benefit analysis, cost estimation of renovation , renovation turn-key service or customer-selected level, energy certificate
Impact	Not known	Not known	Not known	Not known
Technical solutions	Energy-efficient windows and doors, ventilation with a heat recovery, internal extra insulation or new insulation, heat pumps	Heat pumps, floor heating, ventilation, windows, insulation of roofs, extra insulation of exterior walls, façade renovation	Insulation improvements & heating, plumbing, ventilation and sanitation engineering work	Insulation improvements, air heat pump
Energy saving potential	Depends on actions, is separately estimated for each customer	Depends on actions	Depends on actions	Depends on actions, promises even 70 % of the heating energy
Other aspects	Thermal comfort, air quality, living comfort etc. are also taken into consideration.	Living comfort, energy savings	Living comfort	Living comfort, house increases in value
Advantages	Quick, easy, one contracting party	Multifaceted renovation alternatives, one contracting party	Includes financing services, cooperation network	Authorized suppliers, installation work and finishing as turn-key service or customer-selected level, branded concept
Improvement potentials	Financing, wide condition examination, energy monitoring and consumption analyses, and more extensive renovation assortments	Financing, an extensive energy audit and a wide condition examination, and solar energy systems	Energy audit and a condition examination, and change /supplementary of ventilation and heating systems	More extensive renovation assortments. change/supplementary of heating, financing

4 TECHNICAL RENOVATION CONCEPTS

Technical renovation concepts or packages of technical solutions for single-family houses, capable of reducing the final energy use to a very low level in combination with renovation, serve as the base premise for implementation of sustainable renovation of single-family houses. Technical renovation concepts with the potential to result in great energy savings are described. Focus is on technical solutions relevant for renovation of typical single-family houses in the Nordic countries.

4.1 General solutions

This section of the report contains a description of the general solutions for reducing the energy demand of buildings to a very low level and to meet the energy demand with use of the mainly renewable energy supply technologies.

4.1.1 General energy solution

A sustainable energy solution for the entire primary energy use includes an optimal balance between energy savings and renewable energy supply technologies. Examples of renewable sources are solar, wind, hydropower, wave, waste, biomass etc.

Electricity is high quality energy (high exergy), which means that electricity can be used for work, electronics, lighting etc. Therefore, electricity should not be used for energy needs of low quality (low exergy), for example heating and cooling of buildings. It should only be used where absolutely necessary [5] or should be used with high primary energy use efficiency.

Heating of buildings could be based on the use of thermal energy from possible sources, e.g. solar, waste incineration, low temperature heat in combination with heat pumps, and biomass. An energy efficient supply system is when heat is cogenerated with electricity in a district heating plant and supplied to end-user in areas with sufficient heat demand. Such a system also allows for central heat storage facilities that can smooth out the differences in production and consumption of heat. Houses outside a district heating system need other types of heating systems, e.g. ground-source heat pumps or pellet boilers. Heating and cooling of buildings should be minimized by passive measures such as an appropriate building design and orientation, glass area and thermal mass, and any cooling demands must be addressed by natural cooling, i.e. use of natural cold reservoir, for example ground water, sea water and night air.

In a future energy supply system based mainly on renewable energy, e.g. widespread wind power, there is a general problem in relation to widespread individual heating with heat pumps. The amount of electricity needed to operate the heat pumps may not be available in cold winter periods when it is calm, and thus may contribute to increase the need for maximum capacity in the system. There may be a need for the power suppliers to work with the storage and integration of wind power on a large scale.

A significant development in renewable energy supply including storage is expected, but it will probably be cheaper to save energy than to replace use of fossil fuels with renewable energy sources. There are significant economic interests in finding the optimal balance between energy saving and renewable energy supply, so there is a special need to conduct energy system assessments of various options (potential scenarios) so that a rational basis for decision making can be provided. For example, the building and district heating industry may make a joint strategic effort on the development and implementation of low-energy district

heating in connection with new construction and renovation of existing buildings. The built environment should provide qualified boundary conditions for these energy models and analysis.

4.1.2 Energy solution in buildings

Buildings account for about 40% of the total final energy use in the Nordic countries (and EU). Residential buildings are responsible for 70 % of the energy use in buildings in the Nordic countries. In Denmark 75% of which is used in single-family houses. This category of buildings is thereby responsible for half of the final energy use in buildings. Most of the energy used in buildings is for heating of rooms and domestic hot water including electricity for circulating pumps. Electricity is also used in large quantities for building services such as lighting, air conditioning and ventilation, as well as for the electrical equipment used in homes, shops and offices.

A sustainable energy system could combine renewable energy with high energy efficiency. This is highly relevant to buildings, where the potential for energy savings is large, and renewable energy technologies for both heating and electricity are available.

Energy saving in buildings is the subject of much EU energy policy, especially the Energy Performance of Buildings Directive (EPBD) which is implemented in all EU Member States by 2009. The main requirements of the directive are that all fossil-fuel energy used by new buildings must meet a national energy standard, existing buildings (bigger than 1000 m^2 area) must comply with the principles of EPBD whenever they are renovated, and national energy standards must be reviewed every five years to take account of progress in energy saving technologies and fossil fuel prices.

The Danish building codes for example include new energy requirements, which are determined according to the principles of the EPBD. They also introduce two new classes of low energy buildings, which use respectively 50% and 25% less energy than the new energy requirements. The result will be energy savings in both new and existing buildings in Denmark. Similar requirements have been implemented in the other Nordic countries.

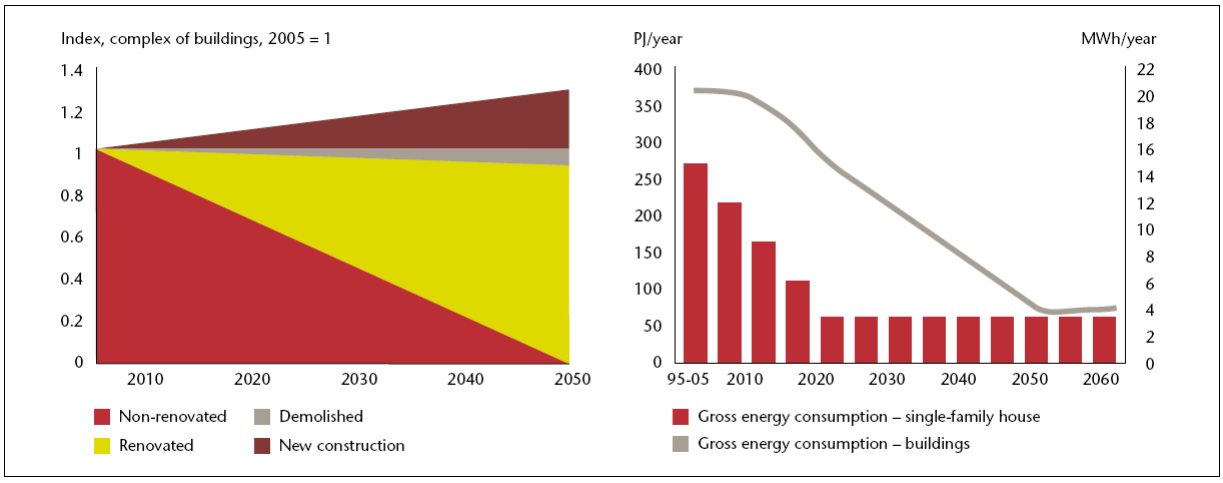

Figure 2: Possible future energy savings in Denmark's housing stock (left), and gross energy use in buildings during the same period (right).

Studies of potential savings in final energy used for heating in existing domestic buildings in Denmark [6,7] has shown that savings of 60-80% in the period up to 2050 are possible if extensive energy saving measures are put in place whenever the buildings are renovated

(Figure 2). The assumption is that during this period the entire building stock is either replaced by new buildings or renovated to the energy standards of new buildings. This would cut Denmark's total final energy use by around 30%. A major part of these savings up to 2050 come from renovation.

There is also potential to save energy through improvements in energy efficiency of appliances. According to statistics the average power consumption in Danish single family houses without electric heating is 4000 kWh/year (in apartment buildings it is 2000 kWh/year).

A suitable approach is to search for a long-term optimal balance between energy savings and supply of renewable energy. Then it will be obvious to investigate the optimal transformation of the existing building stock and its energy system for the entire building stock. The best solutions could be implemented in all new buildings and settlements, and by gradually implementing energy renovations, i.e. combined general renovations and extensive energy savings in existing buildings when a renovation need is identified.

4.1.3 Overall energy renovation

Carrying out holistic and low energy renovations of buildings result in relatively large investments. Therefore it is important that there is a need for a thorough renovation not only based on energy savings. The crucial point is to link the extensive energy savings to the normal renovation measures, in that way reducing the price of implementing the savings. The need for a thorough renovation may typically be due to:

- Physical degradation of main components such as roof, facade and windows.
- Bad thermal indoor comfort, e.g. due to bad insulation, draft from windows or over-heating problems in summertime.
- Health problems, e.g. due to problems with fungi again due to badly insulated walls and bad ventilation or allergic people who have problems with pollen, which infiltrate into the house.
- Wish for an improved overall architecture and use of the house, including rebuilding and extensions.

One of the needs or a combination of the needs mentioned above can as a result have the need for carrying out a thorough renovation of a building, typically comprising renovation of the roof, the facades, changing the windows and establishing a ventilation system. If this is the case, then there is a potential for carrying out a thorough renovation.

4.1.4 Energy renovation measures

The technical energy renovation measures that can be applied in existing buildings on a component level can be described within five categories of measures: Building envelope, building services systems, building supply systems, appliances and continuous commissioning – as described below.

Building envelope

- Internal insulation of exterior walls
- Exterior insulation of exterior walls
- Insulation of cavity walls
- Insulation of thermal bridges, especially foundations
- New energy efficient glazing
- New energy efficient windows and doors
- New removable (secondary) windows
- New roof windows for better daylight conditions, less use of artificial light etc.
- Sun pipes / light ducts for better daylight conditions and less use of artificial light.
- Insulation of slab on ground construction (inside, outside or cavity)
- Insulation of roofs (flat roof, loft, sloped walls, under roof slope, dormers)
- Insulation of crawl spaces (cold or warm) or conversion to slab on ground construction
- Insulation of dividing floor to cold basement including lowering of basement temperature
- Insulation of basement (walls and floor)
- Air tightness measures (based on combined blower door test and thermography)
- Solar shading (overhangs, glazing, mechanical devices)
- Solar walls (vertical solar collector integrated in the building envelope)

Building services systems

- Change to low temperature heating, heaters
- Change to low temperature heating, floor heating (increases heat transmission losses but reduces heat losses from distribution pipe system. Added insulation to the ground and perimeter of the floor is needed)
- Insulation of heating pipes etc.
- New energy efficient circulating pump
- Better (intelligent) control of water based heating and cooling systems, e.g. supplement thermostatic valves with control of supply temperature based on the actual weather
- Ground pre-heating of ventilation, also cooling.
- Tap water (to reduce hot water use)
- Ventilation with heat recovery: natural, hybrid, mechanical
- Change to more efficient ventilation unit including more efficient fans/motors (if there is already mechanical ventilation)
- Utilization of ventilation “free” / night cooling

- Utilization of thermal mass with conventional materials and phase change materials (PCM) (has low impact in energy efficiency houses in Nordic climate)

Energy supply systems

- Change/insulation of district heating unit
- Change/insulation of boiler (gas, oil, wood pellet etc.)
- Change of circulating pump
- Solar heating for hot water
- Solar heating for hot water and space heating
- Photovoltaic's (building integrated)
- Heat pumps (water/water, air/water, air/air)
- District heating with combine heat and power production (CHP) system
- A possibility in near future: Micro CHP systems (e.g. hydrogen or natural gas based) as alternative to individual boilers

Appliances

- New A- labelled white goods or better
- More efficient lighting (fittings, light source, control and regulation equipment)
- More efficient IT equipment
- Change / more efficient other appliances
- Avoid use of electrically heated rails to dry towels
- Wash and dish machines that may directly use hot water produced efficiently by a heating system

Continuous commissioning

- Implementation of metering and control
- Optimization of system operation and control schedules
- User guidelines

4.2 Sustainable low energy renovation concepts

Technical renovation concepts have typically main focus on application of only a few of the available overall technical solutions. We suggest an overall renovation of single-family houses or a step wise planned renovation to be carried out based on design solutions with good combinations of the full range of technical solutions in order to reach a low energy level.

4.2.1 Design strategy

The technical design strategy can be described based on the Trias Energetica concept, which has been developed for the design of low energy buildings in Norway [8]:

1. Reduce the energy demand by avoiding waste and implementing energy saving measures
2. Use sustainable sources of energy instead of fossil fuels
3. Use energy as efficiently as possible

The concept indicates that the most sustainable energy is saved energy. The main benefit of the concept/method is that it stresses the importance of reducing the energy demand before adding systems for energy supply. This promotes robust solutions with the lowest possible environmental loadings.

4.2.2 Technical principles

To reach a low primary energy level, different technical solutions such as renovation of roof, facade, changing windows, installation of energy efficient heating systems, and establishing a ventilation system etc., need to be combined. The technical principles are briefly described below, also indicating the needed level of energy efficiency.

Reduced transmission heat losses

Transmission heat losses are reduced by high standard of insulation of building envelope constructions using preferable integrated system solutions. Reduction of thermal bridges should be reduced to a very low level. Total insulation thicknesses for wall, roof and floor after renovation are around 20 to 40 cm, resulting in U-values of around 0.10 – 0.15 W/m²K, while typical windows are triple-glazed and have positive net energy gains.

Lower transmission heat losses combined with minimized ventilation and air infiltration with a low electricity demand to operate the system reduce the total energy demand significantly. Measures that reduce heat losses are basic measures, which should be implemented before other measures because they are decisive for the renovation of heating installations (e.g. boiler, heat exchanger or heat pump size).

Minimized ventilation heat losses

Ventilation heat losses could be reduced by a mechanical ventilation system with heat recovery that will reduce heat losses by about 80% while increasing both thermal comfort and air quality. The fresh, filtered air is preheated to minimum 17.6°C, assuming for example a room temperature of 22°C and an outside temperature of minimum 0°C.

An annual heat recovery efficiency of 80% or more is possible with modern counter flow plate heat exchangers, or heat exchangers based on the rotating wheel. The latter is widely used in small houses in Finland to cope with the very low winter temperatures. Avoiding ice formation in heat exchangers used in units installed in especially the Nordic countries has become an issue because of the transition towards these high efficient heat exchangers, which

results in a larger cooling of the humid exhaust air. Different controlling strategies and solutions exist to avoid ice formation.

Minimized infiltration heat losses (additional air flow due to wind and stack effect)

A precondition for ventilation with heat recovery is a high level of air tightness of the building envelope, minimizing losses from warm air leaking through cracks and crevices. A standard blower door test with pressurization/depressurization of 50 Pa can document the level of air tightness and visualize the problem areas. A suitable level of air tightness and recommended air change rate per hour (ach) at 50 Pa (n_{50}) is below 1 ach. In comparison the passive house requirement for new houses is below 0.6 ach. To convert the blower door test result n_{50} into yearly average infiltration rate EN ISO 13789 can be used. For moderate shielded buildings, e.g. single-family houses in suburbs, the conversion factor lies in the range from 0.02 (one exposed façade) to 0.07 (two exposed facades). Consequently, a measured n_{50} of 1.0 ach could be converted into an additional air flow rate of 0.02 to 0.07 ach which is equal to 20 to 70% of the ventilation heat loss due to the ventilation system.

Minimized ventilation electricity use

The use of electricity to operate the ventilation system must be minimized. Otherwise the primary energy savings may be mostly loss. A low use of electricity can be ensured using so-called EC fans and a well designed duct system. A sensible level of consumption at 0.5 ach (e.g. the minimum requirement in Denmark) expressed as specific energy use for air transport (SEA-value) is below 600 J/m^3. This is equal to a power consumption of 0.21 W per m^2 floor space area assuming a room height of 2.5m or 21 W for a 100 m^2 house.

Passive solar energy

Having minimized transmission and ventilation heat losses, parameters like window orientation, glazing area and g-value becomes less important. Thus, when replacing windows with low energy windows with a positive energy balance, the window area can be increased and can be determined without regard to orientation. However, this must be balanced against the risk for overheating. In any case, an effective and preferably passive solar shading solution for the house is needed to avoid overheating (see below).

Utilization of internal and solar heat gains

Internal heat gains from people, lighting, equipment etc and solar heat gains can to a very large extent cover the heating demand due to the minimized transmission and ventilation heat losses. Therefore, it is important to use realistic values when estimating the energy saving potential. The standard value for internal heat gains in Denmark is as high as 5 W/m^2 gross floor area. For comparison the passive house method uses an extraordinarily small value of 2.1 W/m^2 net floor area. Measurements on new Danish single-family houses indicate an internal heat gain of about 4 W/m^2. In a house generally equipped with energy-efficient household appliances 3 W/m^2 gross floor can be used.

Minimized hot water demand

The domestic hot water (DHW) consumption varies a lot. The official Danish building energy calculation method operates with a standard value for residential buildings of 250 litres per year per m^2 gross floor area. Assumed heated from 10°C to 55°C, this amount of DHW equals 13 kWh/m^2/year. The energy use does not include heat losses due to production and distribution. In single-family houses in general the heat loss from the hot water tank (if one is present), heat exchangers and the surrounding heating pipes account for a large share of the total heat loss.

Having reduced transmission and ventilation heat losses and having utilized ”free” heat gains, space heating demand is reduced to a low level. The demand for domestic hot water (DHW)

may be partly supplied by installing a solar heating system. In Denmark, for example, a solar heating system for DHW can typically supply a family with 60-70 % of their need for hot water. Solar heating systems for combined DHW and space heating are available. Such a system is of course particularly relevant for a house with a heating demand in the summer period allowing for a shut down of the primary energy source (e.g. boiler) and thereby eliminating the idling heat loss. Relevant buildings are those with limited possibilities of introducing energy efficient renovation measures, for example listed buildings (9,000 of them in Denmark) and in addition buildings that have been assessed to be worthy of preservation (300,000 in DK).

Efficient energy supply

The remaining space heating and hot water demand could efficiently be supplied by, e.g. low energy district heating systems in the cities. Outside the cities the energy supply could come from small and high efficient heat pumps, wood pellet burners or during a transitional period gas/oil boilers etc. Keeping existing heaters in water-based heating systems allow for a lower system temperature and therefore a more efficient production (especially regarding heat pumps) and distribution of the heat demand. Houses without a hydronic system can most of the year comfortably use the ventilation system for space heating.

Solar electricity production by use of photovoltaic in the Nordic countries could be interesting in the future. At the moment photovoltaic's are not profitable either on a large scale or for use in single-family houses but some private house owners may be willing to invest in the technology due to non-economic reasons.

Mainly passive measures for overheating control

Overheating is reduced using mainly passive measures like overhangs and shading devices (e.g. awnings). Glazing for solar control, also in single-family houses, could be an unconventional but relevant option due to a much shorter heating season in low energy renovated houses. Experiences with new low energy houses show that they actually suffer less from overheating than regular houses because the thermal insulation keeps the summer heat out.

A ventilation system with heat recovery should be equipped with a bypass that guides (some of) the air flow round the heat exchanger when heat recovery is not suitable, e.g. in summertime. Potentially the system can be used to cool down the house with cold day and night air. But the cooling capacity though is limited due to the relatively small air change rate in single-family houses, so the solution to overheating is primarily effective solar shading.

Intelligent control and continuous commissioning

An effort to educate the house owner by providing user guidelines on how to use heating and ventilation systems may have a big impact on energy use and thermal comfort etc. This concept of intelligent control and continuous commissioning is relevant in low energy new buildings and also low energy renovated single-family houses to make sure that the expected energy savings are delivered. The energy use is very sensitive to bad operation of heating and ventilation systems, solar shading devices etc. Therefore, an implementation of metering and intelligent control including optimization of systems operation and control schedules is a precondition for a low energy use.

Electrical appliances

Low energy renovation concepts also include appliances. In countries or regions where cheap electricity is not available, it is often very profitable for homeowners to save electricity by change to new A-labelled white goods, more efficient lighting and IT equipment etc.

4.2.3 Non-energy aspects / benefits

Application

Renovation to a low energy level implies a thorough renovation of the house including eliminating or heavily reducing thermal bridges, e.g. by replacing existing windows and in most cases by externally insulating the walls. Another element will be to make the house air-tight and to install a ventilation system with heat recovery. Carrying out a comprehensive low energy renovation requires the set-up of a good planning and means a relatively large investment.

Renovation plan

In order to deal with the large investment costs, it is important that there is a need for a thorough renovation not only based on energy savings. Thorough renovation of the house so to speak "shall be made anyway" as a result of physical degradation of main building components, bad indoor housing comfort, health problems etc.

Durability

Because of the external thermal insulation, the surface temperature is close to the indoor air temperature and therefore the construction is protected from internal condensation and lasts longer. Minimisation of thermal bridges and improved air tightness also reduces structural damages.

Architecture

By using new and better performing materials when renovating buildings to a low energy level, the architectural quality of the building can be improved at the same time. However, building requirements imposed by local authorities and the type of building can often limit the choice of materials to be used.

Indoor environment

The thermal comfort both in winter and summer can be expected to be better than in normal houses. The uniform air renewal and no cold draught provides for good indoor air quality. External thermal insulation and good air tightness avoid condensation and thus growth of moulds and fungus. Internal insulation results in lower temperature of building components and increases the risk of moisture problems. Acoustic improvements can be expected due to the insulation and tightening of the building envelope.

Economy

As an input for estimations of the economic feasibility of energy saving measures, reliable cost data are needed from the start of the planning. If the renovation of the house has to take place anyway, the most interesting cost data for estimating the economic feasibility is not the overall cost of measures, but the extra cost of the energy saving measures.

For most measures and for combinations of measures, the following data are relevant:

- Cost for renovation measure according to national building code
- Cost for recommended low energy renovation measure
- Extra cost of measure compared to measure according to national building code

Besides cost for renovation for the estimations of the economic feasibility the following parameters are relevant:

- Lifetime of insulation measures, windows, heating, ventilation and DHW systems etc.

- Interest rate
- Loan period (calculation time)
- Energy price of electricity, district heating, gas, oil, wood etc.

The economic feasibility of an energy saving measure can be improved by public subsidy.

In general the increased energy performance and modernization of the house will improve the value of the house on the market.

4.2.4 References / further information

General information on low energy renovation is available from the Intelligent Energy Europe project: “Passive house retrofit”.

An internet tool-kit with the information has been developed:

http://www.energieinstitut.at/Retrofit/.

The project report is available via this link:

http://www.energieinstitut.at/Retrofit/Dateien/Startseite/E-RETROFIT-KIT-Publishable-Report.pdf.

5 CONCLUSIONS

5.1 Contribution to overall picture

In the Nordic countries, there are few examples of "full-service" renovation concepts with reasonable success. These concepts have just recently entered the market (e.g. Danish "Clean Tech" concept and Finnish "ENRA"concept) and their success is yet to be evaluated.

The described Swedish full-service example of renovation of heating systems by replacing resistance heaters with a district heating system, shows that a focused and patient marketing campaign with emphasis on economic aspects and functional reliability can sell a package deal to a large share of the target group.

The existing technical renovation concepts, focussing typically on application of only a few of the available technical solutions, have not been successful in realizing large scale energy efficiency gains. Renovation of single-family houses might be carried out based on design solutions with good combinations of the possible range of technical solutions including e.g. "passive measures" like insulation measures and "solar measures" like solar heating in order to reach a low primary energy level.

In the report the key aspects of reaching a low primary energy level in connection with renovation is described in the form of typical energy renovation measures and technical principles of low energy renovation concepts including recommended measures.

5.2 Relation to the state-of-the-art and progress beyond it

Existing renovation concepts need to be developed to include sustainable low energy renovation system solutions, full-service packages including financing and continuous commissioning to make sure the expected energy savings are delivered. The focus should be on making it easy, simple and secure for the consumer to invest in a low energy renovation of their house. The building sector needs easy to use knowledge and initiatives which ensure that they can offer solutions which fulfil the demand for quality, economy and a simple process.

5.3 Impacts to other WPs

The description of existing service concepts for sustainable renovation or service models provides the background for WP2 (marketing strategies) and WP3 (successful service models). WP2 will develop better strategies on how to get the service providers to sell energy efficient or low energy solutions and how to make the customers to buy them. WP3 will be based on lessons learned from WP 1 and 2 to develop win-win service packages including consulting, contract work, follow-up, financing and operation and maintenance.

The remaining work in WP1 will focus on the application of low energy renovation measures / concepts on typical Nordic single-family house with great energy saving potential. The aim is to make an overview of possible energy renovation solutions taking into account both heating and cooling demands and indoor comfort requirements. Other aspects to be analysed are renovation plans, durability issues, user needs and total life cycle cost. The final result of WP1 is proposals for new better sustainable renovation concepts suitable for low energy renovation of different categories of single-family houses.

5.4 Other conclusions and lessons learned

The main objective of the project is to change the business environment in order to speed up the implementation of sustainable renovation of single-family houses. Based on the current status of the renovation market, the authors estimate that to speed up the implementation, not only new better renovation concepts need to be developed, but society needs to help out by making better incentives structures, e.g. increased tax on energy and/or subsidy programmes. Combined with an outlook for rising global energy prices, sustainable renovation of single-family houses has the potential to become an important market area in the future.

6 REFERENCES

[1] EN 15603:2008: Energy performance of buildings – Overall energy use and definition of energy rating. January 2008.

[2] SBi 2008:07: European national strategies to move towards very low energy or passive buildings. Danish Building Research Institute, Aalborg University, and EuroACE, March 2008.

[3] Mahapatra, K and Gustavsson, L. (2009). Influencing Swedish homeowners to adopt district heating system, Applied Energy, 86: 144-154

[4] Telephone conversation on August 17, 2009 with Jörgen Utbult, project leader of Villa Kanndalen project.

[5] Niele, Frank. Energy – Engine of Evolution. Shell Global Solutions. 2005.

[6] Wittchen, K.B. Potentielle energibesparelser i det eksisterende byggeri. SBi 2009:05. ISBN: 978-87-563-1363-6. Statens Byggeforskningsinstitut, Aalborg Universitet, Hørsholm. 2009.

[7] Tommerup, H.; Svendsen, S. (2006). Energy savings in Danish residential building stock. Energy and Buildings, 38, 618-626. 2006.

[8] Dokka, T.K. and Rødsjø, A. (2005). Kyoto Pyramiden. www.lavenergiboliger.no.